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S O M E   C I T R U S   P R O B L E M S.

ROOT FORMATION AND FERTILIZING.

(Continued)

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PROBABLE LOSS OF FERTILIZERS. - In the loss of fertilizers after being applied the following factors are involved: (1) The amount of water supplied by precipitation or irrigation within a given period of time; (2) the chemical composition of the fertilizer and soil; (3) the amount of fertilizer applied at one time; (4) the physical condition of the soil and the inclination of the terrain.

THE WATER SUPPLIED. - The importance of the amount of water reaching the surface of the soil in relation to the loss of fertilizers by leaching or percolation may be illustrated by the following concrete example: In a clay soil containing 65% colloidal matter, the trees have a spread of 20 feet and the fertilizer is applied under the branches. The weight of this soil is 40 Kg. per cubic foot and the water-holding capacity 30% of the weight. The question to be answered is how much rain may fall or how much irrigation water may be applied before fertilizer salts will be carried down below the feeding roots. This question may be answered by means of the following calculations.

With the roots covering an area which is a circle 20 feet diameter, the total root area will be 314.16 sq. ft.

The feeding roots being in the upper 8 inches of soil the root inhabited soil mass will be 209.44 cubic feet.

At 40 Kg. per cubic foot the air-dry soil in the root area will weigh 8377.6 Kg.

With a water-holding capacity of 30% that volume of soil will be saturated with 2513 liters, or 664 gallons.

In percolation the rule is that the fluid applied replaces an equal amount of that present. Therefore, it should be possible to apply 2500 liters of water to this 314 square foot of soil after fertilizing without any of the soluble salts being percolated below the upper 8 inch limit. But practical experience with soils shows that some percolation takes place with an application of three-fourths or less of the water-holding capacity. In this case none of the salts applied were carried below the 8 inch limit when 1400 to 1500 liters water was added, or 4.72 liter per square foot, equal to 2 inches of rain.

In dealing with soils different from the one here considered the above calculations apply provided the weight and water-holding capacity of the air-dry soil is known.

THE CHEMICAL COMPOSITION OF THE FERTILIZER AND SOIL. - The tendency in fertilizing nowadays is to use concentrated salts which are mostly water-soluble; hence the importance of controlling the water supply after fertilizing. Fortunately most soils are not merely filters through which the fertilizer salts, in solution, may pass without change in quantity or quality. In fact most soils are so complex that with present knowledge it is not always possible to predict the changes that may take place in a fertilizer after it has been applied. It is known that organic matter is more or less retentive; that bases in the soil, such as calcium, are replaced by bases in the fertilizer, such as ammonium and potassium; that bases in the soil such as calcium, magnesium, manganese, iron and aluminum, combine with phosphoric acid forming salts which are not water-soluble.

On the basis of this general knowledge a number of citrus soils were examined for the purpose of determining their retentivity towards the various fertilizer salts. Measured soil areas in the field were enclosed by covered frames. Fertilizers were applied within the frames and measured volumes of water were added from time to time. Soil samples from these areas were analyzed from time to time and soil samples of the same types as that within the frames were air-dried, pulverized and used for percolation experiments in the laboratory. The results from this work indicate what may be expected to take place under field conditions.

In the experiments, field as well as laboratory, the fertilizer formula 6-8-10 was used as the basis, applied at the rate of 30 lbs. per tree, because that approaches what many planters are applying to large trees. Thirty pounds of a 6-8-10 mixture supplies 819 gr. nitrogen, 1090 gr. phosphoric acid, P_2O_5, and 1361 grams potash, K_2O. If that is applied on the outer 5 feet of a 20 foot circle it will cover 236 square feet, the soil of which, to a depth of 8 inches, will weigh 6294 Kg., at 40 Kg. per cubic foot. Consequently the fertilizing is at the rate of 130 mg. nitrogen per Kg. soil, 173 mg. P_2O_5 and 216 mg. K_2O, which may also be expressed part per million, abbreviated ppm. The water was always applied in portions corresponding to the total water-holding capacity of the soil.

NITRATE NITROGEN. - When nitrogen is present in fertilizers as nitrates it occurs, usually, in the forms of sodium, potassium or calcium nitrate, which salts are readily soluble in water. No great quantity of nitrate nitrogen is retained by any soil. In the clay soil, formerly mentioned, the probable percolation through the upper 8 inches will be 50% or more of the quantity applied if water amounting to three-fourths of the soil's water-holding capacity is applied shortly after fertilizing, and about another 25% if a similar application is made within a few days. In other words the probable loss from the upper 8 inches of that soil, under a 20 ft. tree as described above, will be about 1 lb. nitrogen by an application of 6 liters water per square foot, or a rainfall of 2.55 inches. And another rain following shortly after will be liable to remove about one-half pound nitrogen, leaving but two to three ounces of the, nearly, 29 ounces applied.

How much the tree roots may remove within a given time is not yet clear but the indications are that the quantity is considerable. Several soil samples from among roots of large trees were examined and only few ppm nitrogen were found three to six weeks after fertilizing. That phase of the problem will be reported upon later.

AMMONIA NITROGEN. - Nitrogen in the form of ammonia occurs in fertilizers, usually as sulphate or phosphate which salts are water-soluble. It is absorbed and held with considerable tenacity by the colloidal matter of the soil so that even very heavy rains remove but a small percent of the amount applied in the fertilizer. The replaceable lime in the soil is of much importance in this respect, and most of the clay soils examined contain enough lime in replaceable form to make the ammonium loss negligible in the drainage water from a rainfall equal to the soil's water-holding capacity. If, however, rains fall equal to twice the water-holding capacity of the soil the ammonia loss may amount to upwards of 20% of the amount applied unless the replaceable lime content is much larger than what it usually is, but, calculated on a clay soil, such precipitation is unusual.

After a few days the ammonia begins to nitrify in the soil, that is, it changes into nitric acid which is subject to loss by leaching, similar to that of the nitrates formerly mentioned. But although nitrification starts soon after fertilizing, all of the ammonia applied is not necessarily converted in a short time. In these experiments where ammonium sulphate was applied in covered frames, appreciable amounts of nitrates was found after a few days, yet some ammonia was present after six weeks. Which shows that loss of nitrogen, by leaching, is very much less with ammonia than with nitrates.

The question is often asked, what is the probable loss of fertilizer salts by evaporation when the fertilizers are not covered by soil? The answer is: None of the salts are volatile. Ammonia may escape into the air if there is much lime on the surface of the soil, but it is not volatile until it is liberated from its acid bond.

PHOSPHORUS. - The phosphorus is present in fertilizers as phosphoric acid which is usually combined with calcium, potassium or ammonium. The two latter combinations are water-soluble as is also one form of calcium phosphate. The loss from leaching is therefore a possibility and undoubtedly some loss takes place in the sandy soils that are deficient in colloidal matter. But from the clay soils, as well as the sandy soils containing some clay, the loss is negligible according to the results from the percolation and covered-frame experiments.

The main loss of phosphorous is usually due to chemical combinations with bases in the soil from which plants cannot recover it. To what extent that takes place in the soils under consideration is not within the scope of this article. But the iron and manganese content was found to be sufficiently high in all of them to provide for possible combinations of phosphates that may supposedly be slowly or entirely inavailable to plants.

POTASSIUM. - The potassium is usually present in fertilizers in combination with one of the following acids: sulfuric, hydrochloric, nitric, phosphoric and occasionally carbonic. These salts are all water-soluble but like ammonia the potash is held by the colloidal matter of the soil and it replaces lime. The results of these experiments show that the loss of potash by leaching is negligible provided the soil contains considerable colloidal matter and replaceable lime.

CALCIUM. - While calcium is present in commercial fertilizers only as a by-product it may properly be considered in this paper for it is as necessary to a citrus tree as are any of the, socalled, fertilizer elements. But aside from that it is, as mentioned previously, very important in connection with leaching of ammonia and potash. Most of the soils examined were found to contain some leachable lime, for instance the clay soil, mentioned previously, yielded in the first percolate 22 ppm CaO, but the second percolate none. After applying an ammonia or potash salt, and continuing the percolations, the first percolate contained 25 ppm, the second 45 ppm, the third 22 ppm, the fourth 10 ppm, and the fifth 4 ppm. Which shows that a small amount of the lime present would be lost in the first rain, but the rest of it the soil was capable of holding, at

least until it should become more soluble. Yet the soil was not capable of retaining it after the ammonia or potash salts were applied. Seventy ppm were leached out in the first two percolates corresponding to 8 inches of rain and corresponding amounts of the other salts were retained by the soil.

The importance of lime in relation to phosphoric acid is also worth considering. It converts the water-soluble monobasic phosphate into the insoluble tribasic form which is undesirable. Yet tribasic calcium phosphate is more readily available to plants than are the iron and aluminum combinations and probably the latter feature outweighs the former.

THE AMOUNT OF FERTILIZER APPLIED AT ANY ONE TIME. - Soils containing an abundance of colloidal matter and replaceable bases are capable of retaining considerable quantities of ammonia, potash and phosphate, and in many cases the loss of these ingredients by leaching may not be much greater when 30 to 60 lbs. are applied per tree than if only 15 pounds were applied. But in most cases the loss is liable to be comparatively great if very heavy rains fall shortly after the fertilizer has been applied. In the case of nitrate nitrogen there is no question but what the loss will be great under those conditions. How best to proceed is largely a local problem. If heavy rains are not to be feared large applications may be made. If, on the other hand, heavy rains may be expected the question becomes one of the probable value of the fertilizers lost by leaching, against the cost of making one or more extra applications.

THE PHYSICAL CONDITION OF THE SOIL AND THE INCLINATION OF THE TERRAIN.

It is superfluous to state that water runs down hill and that aside from gullying the soil it carries with it all the water-soluble matter. In some soils erosion is less a problem than in others due to the rapid absorption of the rain-water as it falls. Some of the tobacco soils on the steep hills in the Comerio district, which have been under cultivation for many years, may be pointed to as an example. In some of the heavy clay soils erosion is not as serious a problem, while the soil is covered with vegetation, as it is after the vegetation is removed, which is not due entirely to the fact that vegetation arrests the soil but partly so to the more or less porous condition of a soil permeated by plant roots.

This naturally suggests a system of cultivation in which the sod between the trees is left undisturbed. All of the fertilizer will naturally be applied on the hillside above the tree, especially in view of the fact that the main portion of the roots are there, as explained in the first part of this article. If a ditch is dug, running crosswise of the slope between the trees, for the purpose of catching the run-off, it should preferably be close enough to one of the rows to allow the roots of the trees in that row to get the benefit from it. Naturally, a heavy mulch around the trees will greatly minimize the run-off.